

Swift Observations of GRB 101011A

*J. K. Cannizzo (NASA/UMBC), C. B. Markwardt (NASA/GSFC),
T. N. Ukwatta (GWU), A. Rowlinson (U. Leicester),
M. de Pasquale (MSSL-UCL), for the Swift Team*

1 Introduction

BAT triggered on a long burst, GRB 101011A, at $T = 16:58:35$ UT (trigger=436094). (Cannizzo, et al., *GCN Circ.* 11331). *Swift* slewed immediately to the burst. The BAT on-board calculated location is RA, Dec = (48.298, -65.986) deg, which is {03h 13m 12s; $-65^{\circ} 59' 08''$ } (J2000) with $\sigma = 3$ arcmin (radius, 90% containment, including systematic uncertainty). The BAT light curve showed about 5 peaks with a duration of ~ 50 s. The peak count rate was ~ 3000 c s $^{-1}$ (15 – 350 keV), at $\sim T$ s.

The XRT began observing the field at 16:59:53.5 UT ($T + 78.2$ s). XRT found a bright, fading, uncatalogued X-ray source located at RA, Dec = (48.29427, -65.98212) deg, which is {03h 13m 10.62s; $-65^{\circ} 58' 55.6''$ } (J2000) with $\sigma = 3.8$ arcsec (radius, 90% containment). This location is 14 arcsec from the BAT onboard position. The initial flux in the 2.5 s image was 6.35×10^{-10} erg cm $^{-2}$ s $^{-1}$ (0.2 – 10 keV).

UVOT took a finding chart exposure of 150 s with the White filter starting at $T + 84$ s. No credible afterglow candidate was found in the initial data products. The $2.7' \times 2.7'$ sub-image covers 100% of the XRT error circle. The typical 3σ U.L. has been about 19.6 mag. The $8' \times 8'$ region for the list of sources generated on-board covers 100% of the XRT error circle. The list of sources is typically complete to about 18 mag. No correction has been made for the expected extinction corresponding to $E(B - V)$ of 0.18.

The burst was also seen by *INTEGRAL* SPI/ACS ($T = 16:58:35$ UT¹).

2 BAT Observation and Analysis

Using the data set from $T - 240$ to $T + 302$ s, further analysis was performed (Markwardt et al. *GCN Circ.* 11332). The BAT ground-calculated position is RA, Dec = (48.274, -65.990) deg which is {03h 13m 05.7s $-65^{\circ} 59' 23.2''$ } (J2000) with an uncertainty of 1.2 arcmin, (radius, sys+stat, 90% containment). The partial coding was 87%.

The BAT light curve shows an initial FRED-like pulse starting at $\sim T - 0.3$ s, peaking at $\sim T + 0.6$ s, then followed by several other weaker peaks lasting out to $\sim T + 90$ s. T_{90} (15 – 350 keV) is 71.5 ± 18.3 s (estimated error including systematics).

The time-averaged spectrum from $T - 0.4$ to $T + 84.2$ s is best fit by a simple power-law model. The power law index of the time-averaged spectrum is 1.24 ± 0.14 . The fluence in the 15 – 150 keV band is $1.4(\pm 0.1) \times 10^{-6}$ erg cm $^{-2}$. The 1-s peak photon flux measured from $T - 0.22$ s in the 15 – 150 keV band is $1.3(\pm 0.2)$ ph cm $^{-2}$ s $^{-1}$. All the quoted errors are at the 90% confidence level.

¹<http://www.isdc.unige.ch/integral/ibas/results/triggers/spiacs/2010-10/2010-10-11T16-58-35.00-00000-00000-0.png>

3 XRT Observation and Analysis

Using 1274 s of XRT Photon Counting mode data and 2 UVOT images (Evans et al. GCN Circ. 11333), an astrometrically corrected X-ray position is found (using the XRT-UVOT alignment and matching UVOT field sources to the USNO-B1 catalogue): RA, Dec = (48.29486, -65.98182) which is {03h 13m 10.77s; $-65^{\circ} 58' 54.5''$ } (J2000) with $\sigma = 1.4$ arcsec (radius, 90% confidence).

Analysis of 3.9 ks of XRT data (Rowlinson & Cannizzo GCN Circ. 11335), from $T + 66$ s to $T + 7.2$ ks was carried out. The data comprise 86 s in Windowed Timing (WT) mode (the first 8 s were taken while *Swift* was slewing) with the remainder in Photon Counting (PC) mode. The enhanced XRT position for this burst was given by Evans et al. (GCN. Circ 11333).

The light curve can be modeled with a series of power-law decay. The initial decay index is $0.8(+0.5, -1.7)$. At $T + 116$ s the decay steepens to $2.49(+0.18, -0.19)$ before breaking again at $T + 656$ s to a final decay of $1.13(+0.28, -0.25)$.

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of $1.41(+0.20, -0.19)$. The best-fitting absorption column is $7.6(+6.0, -4.3) \times 10^{20}$ cm^{-2} , consistent with the Galactic value of 3.3×10^{20} cm^{-2} (Kalberla et al. 2005). The PC mode spectrum has a photon index of $1.94(+0.26, -0.30)$ and a best-fitting absorption column of $1.5(\pm 0.8) \times 10^{21}$ cm^{-2} . The counts to observed (unabsorbed) 0.3 – 10 keV flux conversion factor deduced from this spectrum is 4.2×10^{-11} (5.7×10^{-11}) $\text{erg cm}^{-2} \text{c}^{-1}$.

4 UVOT Observation and Analysis

The *Swift*/UVOT began settled observations of the field of GRB 101011A at $T + 85$ s (De Pasquale & Cannizzo, GCN 11338). Summing up white band exposures up to $T + 1374$ s, including the finding chart, we find a strong indication (2.9σ) of an uncatalogued source at RA, Dec = (48.29487, -65.98167) which is {03h 13m 10.77s; $-65^{\circ} 58' 54.0''$ } (J2000) with $\sigma = 1.1$ arcsec. This refined position is within 0.5 arcseconds from the XRT refined position (Evans et al., GCN Circ. 11333) and supersedes the one given in Holland et al. (GCN Circ. 11334). In the individual and summed UVOT exposures in other filters, no optical afterglow is detected. Preliminary 3σ upper limits using the UVOT photometric system (Poole et al. 2008, MNRAS, 383, 627) for the first finding chart (FC) exposure and subsequent exposures are:

Filter	T_start	T_stop	Exp(s)	Mag	Err
white(FC)	85	235	147	>21.3	
white	85	1374	373	21.7	+/-0.4
white	4311	6627	393	>22	
v	627	18725	1375	>20.8	
b	533	41918	1055	>21.4	
u	297	41737	2865	>22.0	
uw1	577	47696	2595	>21.7	
um2	652	46017	2996	>21.7	
uw2	603	17812	376	>21.5	

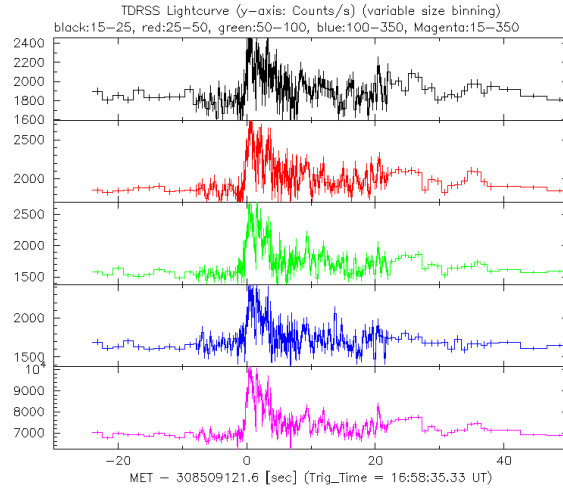


Figure 1: BAT Lightcurve. The light curve in the 4 individual plus total energy bands (15 – 25 keV, 25 – 50, 50 – 100, 100 – 350, and 15 – 350).

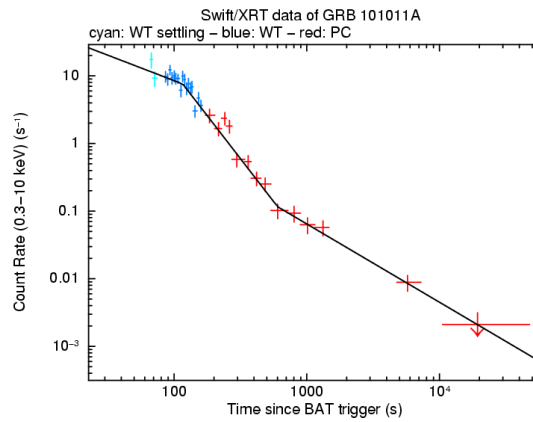


Figure 2: XRT Lightcurve. A broken powerlaw fit gives: $\alpha_1 = 0.75(+0.11, -0.37)$, $t_{\text{break}, 1} = 116(+12, -8)$ s, $\alpha_2 = 2.54(+0.16, -0.17)$, $t_{\text{break}, 2} = 602(+175, -88)$ s, $\alpha_3 = 1.16(+0.22, -0.19)$.

The values quoted above are not corrected for the Galactic extinction due to the reddening of $E(B - V) = 0.03$ in the direction of the burst (Schlegel et al. 1998).